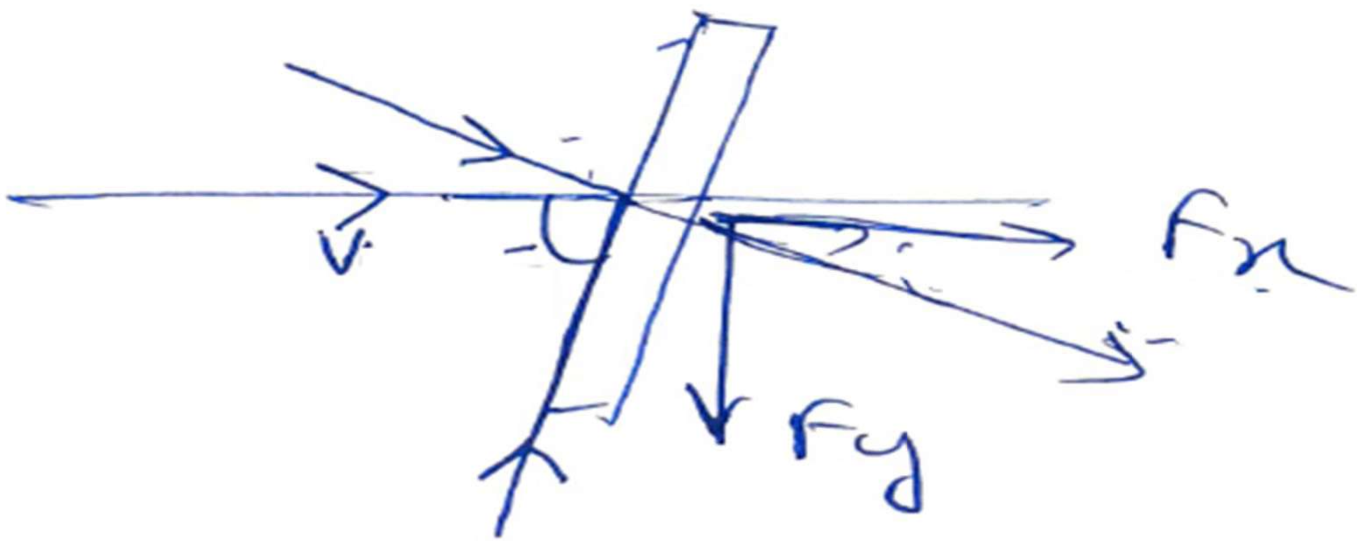
A 7.5 cm diameter jet having a velocity of 30 m/s strikes a flat plate, the normal of which is inclined at 45° to the axis of the jet. Find the normal pressure on the plate : (i) when the plate is stationary , and (ii) when the plate is moving with a velocity of 15 m/s and away from the jet. Also determine the power and efficiency of the jet when the plate is moving.



(a)

$$F_n = \dot{m}\,[V_{1x} - V_{2x}] \rightarrow$$

$$= \rho A V\,[V \sin 45 - 0]$$

$$= 1000 \times \frac{\pi}{4} \times (.075)^2 \times 30^2 \times \sin 45$$

$$= 2810.98 \text{ N}$$

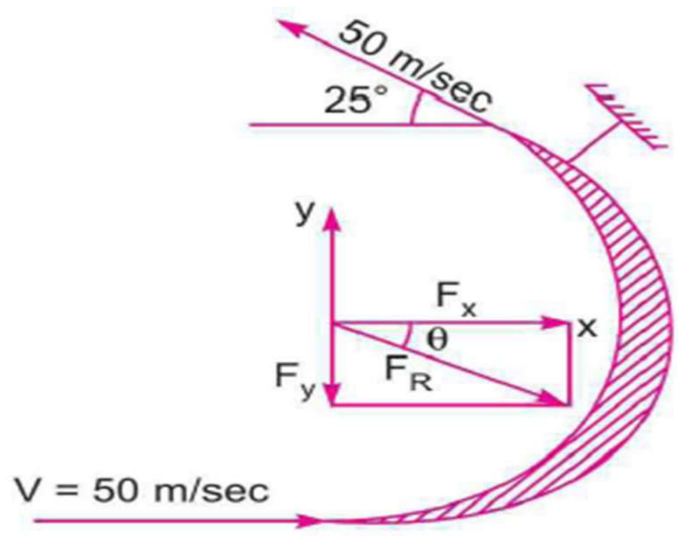
$$F_n = \rho A (V - u)\,[(V_1 - u) \sin 45]$$

$$= 1000 \times \frac{\pi}{4} \times (.075)^2 [30 - 15]^2 \sin 45$$

$$= 702.87 \text{ N}$$

(a) A stationary vane having an inlet angle of zero degree and an outlet angle of 25° as shown in Fig. , receives water at a velocity of 50 m/s. Determine the components of force acting on it in the direction of the jet velocity and normal to it. Also find the resultant force in magnitude and direction per unit weight of the flow.

(b) If the vane stated above is moving with a velocity of 20 m/s in the direction of the jet, calculate the force components in the direction of the vane velocity and across it, also the resultant force in magnitude and direction. Calculate the work done and power developed per unit weight of the flow.



Given

$\theta = 0°$

$\phi = 25°$

$v = 50$ m/s

F_x for unit of flow $= m^0 (V_{1x} - V_{2x})$

$= \rho A V [V + V\cos 25°) / \rho A V . g$

$= \dfrac{(1 + \cos 25) V}{g}$

$= \dfrac{(1 + \cos 15) \times 50}{9.81} = 9.27$ N/N

Fy/ unit of flow

$$= \dot{m} (V_{1y} - V_{2y})$$

$$= \rho AV [0 - V \sin 25) / \rho AV g$$

$$= -\frac{V \sin 25}{g} = -2.15 \text{ m/s}$$

$$\tan\theta = \frac{F_x}{F_y} = \frac{2.15}{9.27} \Rightarrow \theta \Rightarrow 12.48^\circ$$

$$R = \sqrt{F_x^2 + F_y^2} = 9.94 \text{ N/m}$$

$$F_x = \rho A(v-u)[(v-u) + v-u \cos 25]$$

$$= \rho A(v-u)^2[1+\cos 25] / \rho A g (v-u)$$

$$= \frac{1000 \times \frac{\pi}{4} .075^2 \times [50-20]^2 (1+\cos 25]}{\rho A (v-u) g}$$

$$= 5.85 \text{ N/N}$$

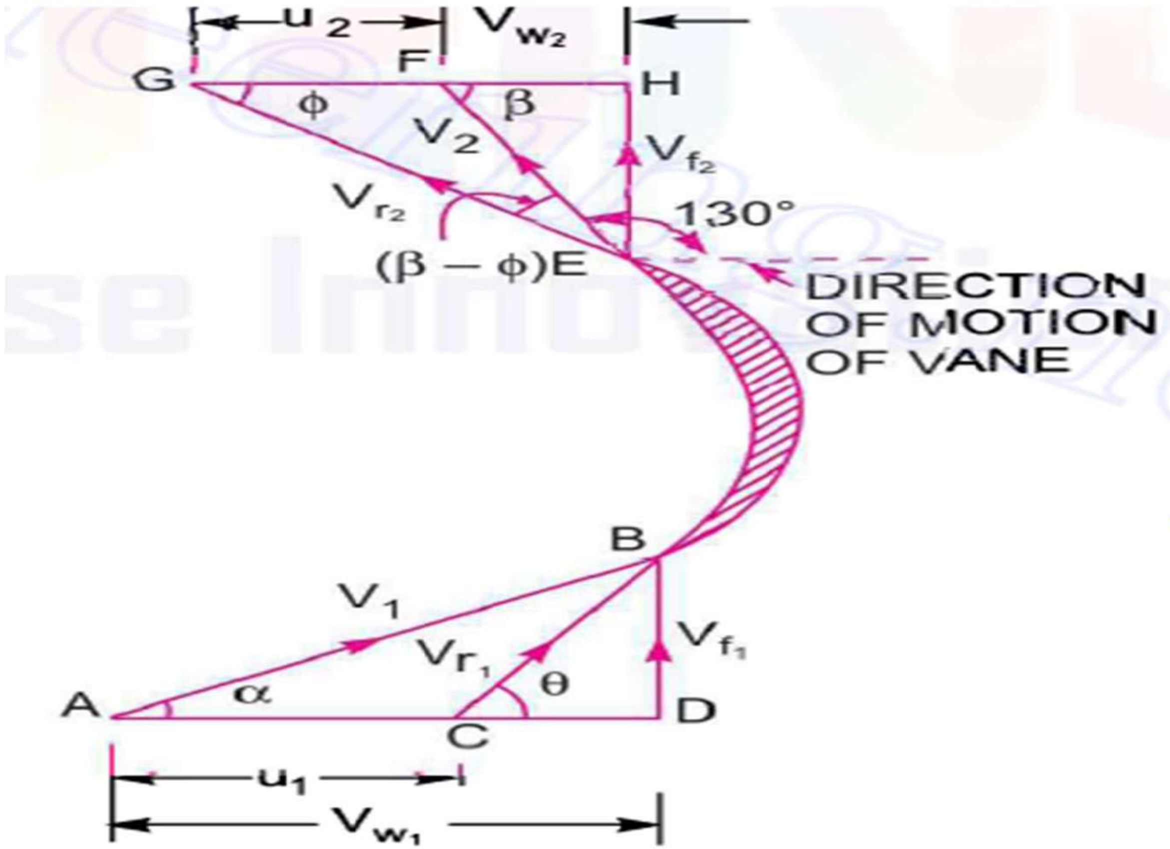
$$F_y = \frac{-\rho A (v-u)^2 \sin 25}{\rho A (v-u) g} = -\frac{(v-u)}{g} \sin 25$$

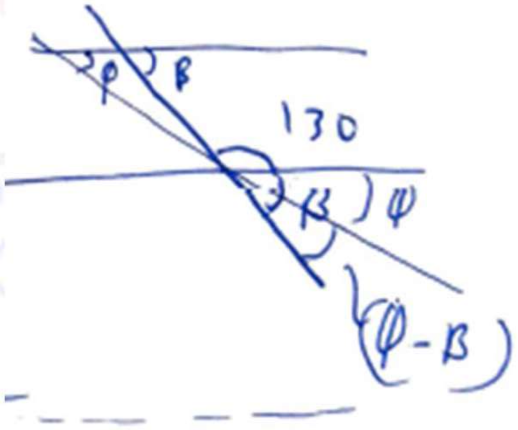
$$= -1.29 \text{ N/N} (\downarrow)$$

A jet of water having a velocity of 20 m/s strikes a curved vane, which is moving with a velocity of 10 m/s. The jet makes an angle of 20° with the direction of motion of vane at inlet and leaves at an angle of 130° to the direction of motion of vane an outlet. Calculate :

(i) Vane angles, so that the water enters and leaves the vane without shock.

(ii) Work done per second per unit weight of water striking (or work done per unit weight of water striking) the vane per second.





$\theta = ?$

$\phi = ?$

$V_1 = 20$ m/s $\quad \alpha = 20 \quad V_1 \rightarrow$ direction of motion

$u = 10$ m/s

$\beta = 180 - 130 = 50$

in $\triangle BDC$

$$\tan\theta = \frac{V_{f_1}}{V_{w_1} - u} = \frac{BC}{DC}$$

$V_{f_1} = V_1 \sin\alpha$

$V_{w_1} = V_1 \cos\alpha$

$V_{w_1} = V_1 \cos\alpha$

$= 18.79$

$V_{f_1} = V_1 \sin\alpha$

$= 20 \times \sin 20$

$= 6.84\ m/s$

$$\tan\theta = \frac{6.84}{18.79 - 10}$$

$\boxed{\theta = 37.87^\circ}$ Vane angle at Inlet

$$\sin\theta = \frac{V_{f_1}}{V_{r_1}}$$

$$\sin 37.87 = \frac{6.84}{V_{r_1}}$$

$$\boxed{V_{r_1} = = 11.143}$$

$$V_{r_2} = 11.143 \text{ m/s}$$

in DEFG sine rule -

$$\frac{V_{r_2}}{\sin 180-\beta} = \frac{u}{\sin(\beta-\varphi)}$$

$$\frac{11.142}{\sin 50} = \frac{10}{\sin(50-\varphi)}$$

$$\frac{11.142}{\sin 50} = \frac{10}{\sin 50-\varphi}$$

$$\sin 50-\varphi = .687$$

$$50-\varphi = 43.43$$

$$\varphi = 6.56^\circ$$

Workdone/sec/unit wt of Fluid strike/sec $= \frac{u}{g}[V_{w_1} + V_{w_2}]$ $\beta < 90°$

$V_{w_2} = GH - FG$

$= V_{r_2} \cos 6.56 - u$

$= 11.142 \cos 6.56 - 10$

$= 1.06$

$W/S/wt = \frac{10}{9.81}[18.79 + 1.06)$

$= 20.24$ /N